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MAE2450-002 Spring 2025

Programing Assignment 4

Problem 1:

Global Parameters:

```python
#Initial Conditons
rho_droplet = 1000 # kg/m^3
rho_air = 1.2 # kg/m^3
mu_air = 1.48e-5 # m^2/s
g = 9.81 # m/s^2
droplet_diameter = np.array([1e-6, 2e-6, 4e-6, 8e-6, 1.6e-5, 3.2e-5, 6.4e-5, 1.28e-4]) # m
radius = np.array([]) # m
V_droplet = np.array([]) # m^3
A_droplet = np.array([]) # m^2
mass_droplet = np.array([]) # kg
for i in range(len(droplet_diameter)):
    radius = np.append(radius, droplet_diameter[i]/2)
    V_droplet = np.append(V_droplet, (4/3)*np.pi*(radius[i]**3))
    A_droplet = np.append(A_droplet, np.pi*(radius[i]**2))
    mass_droplet = np.append(mass_droplet, (np.pi/6)*(droplet_diameter[i]**3)*rho_droplet)
h = 1.75 # m (initial height)
u0 = np.array([1.5, 10, 20, 30, 40, 50]) # m/s (initial velocity)
# Time Parameters
t_span = (0, 1) # s
max_dt = 1 # s
```

Plot showing vertical distance traveled over time

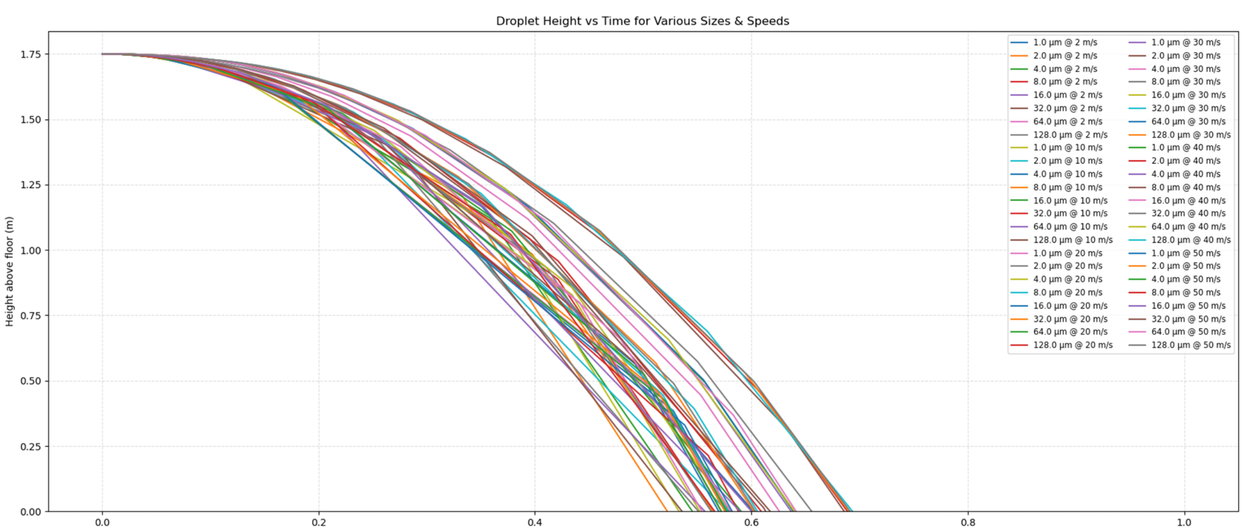

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Table showing distance traveled:

Horizontal distance traveled (m) by droplet size and initial speed:

	1.5 m/s	10.0 m/s	20.0 m/s	30.0 m/s	40.0 m/s	50.0 m/s
1.0 µm	0.000024	0.000050	0.000080	0.000108	0.000135	0.000161
2.0 µm	0.000097	0.000198	0.000309	0.000413	0.000509	0.000600
4.0 µm	0.000386	0.000775	0.001174	0.001527	0.001842	0.002126
8.0 µm	0.001539	0.002972	0.004306	0.005394	0.006313	0.007109
16.0 µm	0.006098	0.011078	0.015092	0.018085	0.020473	0.022459
32.0 µm	0.023623	0.039596	0.050351	0.057722	0.063336	0.067871
64.0 µm	0.084114	0.130901	0.156814	0.173466	0.185764	0.195520
128.0 µm	0.237666	0.361989	0.419492	0.454992	0.480754	0.500989

Table showing time to hit ground:

	1.5 m/s	10.0 m/s	20.0 m/s	30.0 m/s	40.0 m/s	50.0 m/s
1.0 µm	0.597715	0.597721	0.597723	0.597724	0.597725	0.597725
2.0 µm	0.597830	0.597853	0.597861	0.597865	0.597868	0.597870
4.0 µm	0.598217	0.598305	0.598333	0.598348	0.598357	0.598363
8.0 µm	0.599471	0.599802	0.599896	0.599941	0.599967	0.599985
16.0 µm	0.603295	0.604483	0.604767	0.604890	0.604959	0.605003
32.0 µm	0.613724	0.617693	0.618459	0.618761	0.618924	0.619025
64.0 µm	0.635888	0.647836	0.649687	0.650369	0.650724	0.650942
128.0 µm	0.662627	0.692399	0.696434	0.697870	0.698607	0.699056

I used the built in RK45 to conduct my ODE calculations as shown:

```python
for speed in u0:
    distances = []
    fall_times = []
    for D, mi, Ai in zip(droplet_diameter, mass_droplet, A_droplet):
        sol = solve_ivp(
            fun=lambda t, st: droplet_deriv(t, st, mi, Ai, D, rho_air, mu_air, rho_droplet, g),
            t_span=t_span,
            y0=[0, h, speed, 0],
            method='RK45',
            events=lambda t, st: ground_event(t, st, h),
            max_step=max_dt,
            rtol=1e-6, atol=1e-9
        )
        distances.append(sol.y[0, -1])
        if sol.t_events[0].size > 0:
            fall_times.append(sol.t_events[0][0])
        else:
            fall_times.append(sol.t[-1])
    results[speed] = distances
    times[speed] = fall_times
```

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For my time step I determined 1 to be the best number in a range of 0-1 due to the fact that most of my droplets where hitting the floor, before the 1 second mark, as well as anything smaller than the 1 step, took my computer and excessively long time to run, over 15 minutes and no results, so I concluded that this would be the best step size, which resulted in fairly clean results. I do realize that I am probably missing a couple different droplet sizes and speeds, but this was what my computer was able to run.